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Electric Drive at the Basis of a Permanent Magnet Motors and Methods of Controlling Them

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In the context of industry orientation on energy-saving technologies, more and more attention is paid to energy-efficient electric drives. One of these electric drives is an electric drive based on permanent magnet synchronous motors (PMSM).

Permanent magnets have not been used for electrical machines for a long time because the development of the permanent magnet materials was not mature until mid-20th century. After the invention of Alnico and Ferrite materials, permanent magnets were widely used for DC machines in small power applications, such as automobile auxiliary motors. Recently, the improvement of the quality of permanent magnet materials and the technical advances of the control methods allow replacing induction machines with permanent magnet machines in many industrial areas [1].

With the development of permanent magnet materials and the techniques driving an electric machine, the use of PMSMs has increased in many industrial areas by replacing induction motors because of PMSMs advantages in efficiency and size [1]. However, permanent magnet motors tend to be more expensive than AC induction motors and have been known to be more difficult to start up than AC induction motors.

Permanent Magnet motor drives are developed for many applications such as machine tools, compressors, pumps,

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friction welding units, turbine generators. The use of high speed motor drives is essentially aimed at removing the mechanical gear and reducing the overall system dimensions. The permanent magnet motor drives are attractive for high speed operations when variable-speed is required. They can be designed in different forms and exhibit high efficiency in a wide range of operation [2].

Depending on the requirements of each application, different methods can be used to control PMSMs. This article introduces scalar control as a simple control method, which is suitable for low-cost drive systems, and vector control as a more advanced option, which is well-suited for applications that demand higher dynamic performance [3].

In drive systems where simple, low-cost control is desired and where reduced dynamic performance is acceptable, open-loop control methods can be used. Typical applications of such systems include pump and fan drives. Open-loop control methods (or scalar control methods, as they are often called) exist in different variations, which include V/f schemes. Despite their simplicity and their ability to operate over a wide speed range, it has been found that the performance of open-loop methods often depends on the motor parameters and the load conditions of the system. Such methods can experience power swings within specific speed ranges, which might cause the motor to lose synchronism. Furthermore, the behaviour of some open-loop schemes is heavily dependent on the selected parameters of the controller. The selection of the control settings for these schemes is often based on a trial-and-error approach and is therefore quite time-consuming [3].

For more advanced drive systems, which require higher dynamic performances, vector control is a more appropriate option than scalar control. Demanding applications that need vector control can be found, for instance, within the automotive industry. Vector control allows the torque and the flux of the

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PMSM to be controlled separately from each other, through a control structure which is similar to that of a separately excited DC machine. This decoupled control results in the precise and efficient regulation of the motor. However, a major issue with vector controllers is that their operation requires information about the rotor position and the speed of the PMSM. The most direct approach for obtaining this information is the use of mechanical sensors on the shaft of the PMSM [4].

Despite the variety of modern types of PMSM and methods of controlling them, they continue to develop, due to the orientation of the industry towards energy-saving technologies and the expansion of the scope of PMSM.

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